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# Pre-Employment Low Back X Rays
# An Overview

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BRH
bureau of radiological health

WHO Collaborating Centers for:
- Standardization of Protection Against Nonionizing Radiations
- Training and General Tasks in Radiation Medicine
- Nuclear Medicine

August 1981

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Food and Drug Administration
Bureau of Radiological Health
Rockville, Maryland 20857

## FOREWORD

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These reports provide a mechanism for disseminating results of Bureau and contractor projects. They are distributed to Federal, State, and local governments; industry; hospitals; the medical profession; educators; researchers; libraries; professional and trade organizations; the press; and others. The reports are sold by the Government Printing Office and/or the National Technical Information Service.

The Bureau also makes its technical reports available to the World Health Organization. Under a memorandum of agreement between WHO and the Department of Health and Human Services, three WHO Collaborating Centers have been established within the Bureau of Radiological Health, FDA:

WHO Collaborating Center for Standardization of Protection Against Nonionizing Radiations;

WHO Collaborating Center for Training and General Tasks in Radiation Medicine; and

WHO Collaborating Center for Nuclear Medicine.

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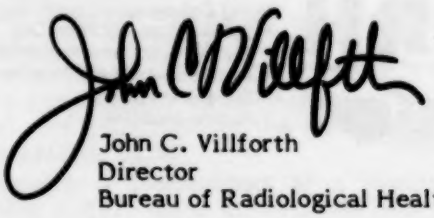

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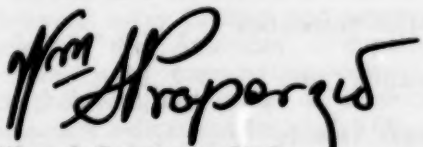
## PREFACE

Routine radiography of the lower spine of prospective employees has been commonplace for some time in a number of industries engaged in heavy labor. Reported use of the low back x-ray examination for screening purposes dates from the 1940's. The efficacy of the pre-employment low back x ray is a strongly debated topic, particularly within industries where heavy or strenuous labor is required. This overview is a summary of the literature and an exploration of the issues related to the low back x-ray examination. The report reviews the objective, protocol, costs, efficacy, medicolegal aspects, and risks of the examination.

The Bureau of Radiological Health encourages a continuing study of the efficacy of this procedure. The Bureau expects to use this overview for future program planning in this area. The report is also provided as information for those radiologists and other physicians engaged in occupational medicine.



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The opinions and statements contained in this report do not necessarily represent the views or the stated policy of the World Health Organization (WHO).

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# PRE-EMPLOYMENT LOW BACK X RAYS: AN OVERVIEW

## INTRODUCTION

For some time, the practice of routinely radiographing the lower spine of prospective employees has been a custom of a number of industries involving heavy labor. Reports describing industrial experience with the use of this examination as a screening tool date from the 1940's (1,2). As early as 1952, Colcher and Hursh observed that, "It (low back x-ray screening) has become an established procedure in some of the large industries where hazardous and heavy skilled labors are involved" (3).

Current discussion of this issue in the medical literature reflects the fact that workers continue to be subjected to lower spine examinations as a condition for employment. In 1973, a conference on low back x rays in pre-employment physical examination was convened. The conference was jointly sponsored by the American College of Radiology (ACR), the American Academy of Orthopaedic Surgeons (AAOS), and the Industrial Medical Association (IMA), in cooperation with the Department of Health, Education, and Welfare (now Department of Health and Human Services (HHS)) (4). Among several conclusions reached at this conference was one stating, "There is a need for the development of appropriate clinical and statistical studies to demonstrate the presence or absence of correlations between x-ray findings and subsequent development of spinal disabilities." More recently, the American Occupational Medical Association recommended that, "Lumbar spine x-ray examinations should not be used as a routine screening procedure for back problems, but rather as a special diagnostic procedure available to the physician on appropriate indications for study" (5).

Possible widespread use of the low back x-ray examinations as a screening device is of concern because of its potential public health and medicolegal ramifications. There is considerable doubt about the efficacy of the examination, especially regarding its utility as a predictor of future work-related back disability. This suggests that the practice may constitute a source of unnecessary population exposure to radiation and unnecessary costs in diagnostic radiology. Therefore this overview was developed to assess the frequency of use and probable impact of the low back screening x-ray examination.

## EXAMINATION OBJECTIVE

Various reasons are given in the literature for making the low back x-ray examination a part of the pre-employment physical examination. Paramount, perhaps, is the belief in liability protection afforded the employer. It has been stated that ". . . the employer is legally permitted to protect himself from liability due to a preexisting spinal weakness . . ." (6). If a condition is detected that might form the basis for future medicolegal action, then that applicant is often rejected. The economic incentive to eliminate applicants who have low back instability as a result of anomalies, disease, or previous traumatic pathology has been cited specifically by the railroad industry (3).

Optimization of manpower through selective job placement is another reason frequently mentioned in support of pre-employment examinations (7-11). That is, the examination becomes a part of a screening program that is often labeled pre-placement rather than pre-employment in nature.

## ROLE OF X RAYS IN SCREENING

For the most part, lumbosacral radiographs are usually viewed as only one element of the pre-employment examination process. Several authors have emphasized that radiographic classification is just one of the many factors to be evaluated when judging employability (12-15).

Occasionally, despite the results of the screening process, an extraneous consideration influences the decision to accept or reject an applicant. For example, supply and demand in the labor pool sometimes necessitates acceptance of workers who might otherwise be categorized as unqualified. Acute shortages of manpower were cited as reasons for lowering the rejection rate from 51 percent to 30.5 percent by a company urgently in need of heavy handlers (2). Another company found that its 16.2 percent rejection rate was simply not feasible given its high personnel turnover and seasonal fluctuations in workload (18).

## EXAMINATION PROTOCOL

The pre-employment x-ray examination of the lower back often entails multiple projections (2-3,6-7,15-18). Table 1 lists the projections used for pre-employment low back x-ray examinations. Research shows that these examinations commonly consist of four views.

Table 1. Projections commonly used for pre-employment low back x-ray examinations

| Researcher | Reference | Projections/Examination |
|---|---|---|
| Becker | (7) | AP, lateral lumbosacral, obliques if needed |
| Burch | (6) | AP, PA, lateral, lateral of the lumbosacral joint, right and left oblique |
| Colcher | (3) | AP, lateral of lumbar spine and sacrum, left and right obliques of lumbosacral area |
| Moreton | (15) | AP, lateral, right and left obliques |
| Redfield | (16) | AP, lateral, left and right obliques |
| Reiner | (18) | AP, lateral |
| Stewart | (2) | AP, lateral |

Some of the projections that are used may, in fact, not be necessary. A study by Rhea et al. found that the oblique view had a very low diagnostic and therapeutic yield in adult patients (19). A similar consideration of the standard combination of a full lateral view and a coned lateral view of the lumbosacral junction led to the assertion that the latter could often be eliminated without hindering diagnosis (20). In a related study at a Veterans Administration Hospital, it was determined that the optimum radiographic examination of the lumbar spine for evaluation of compensation claims was an anteroposterior view in conjunction with a single, well centered lateral view (21).

## FREQUENCY OF USE

At present, there is no way of knowing how many pre-employment, low back x-ray examinations are actually being performed yearly. Available data, however, indicate that the number may be substantial. A recent estimate of examinations done in response to corporate or institutional health policy in the State of Michigan put the number at 63,100 per year in that State (22).

It was estimated during the 1973 ACR Conference that the number of yearly pre-employment lumbar x rays was somewhere between 150,000 and 1,200,000 (4).

Although the Bureau of Radiological Health's (BRH) "1970 X-Ray Exposure Study" did not classify x-ray examinations for pre-employment purposes, some inferences, nonetheless, may be drawn from this source (23). Lumbar spine examinations done in industrial clinics or by physicians whose speciality was occupational medicine totaled 107,000. Of course, the fraction of those that might have been pre-employment examinations is unknown, but is likely to have been significant.

The potential size of the worker population that eventually could be required to undergo this examination may be inferred from Department of Labor data statistics. In 1980, 38,500,000 blue-collar workers were employed in five selected major categories (mining, construction, manufacturing, transportation, public utilities) (24). Studies of the low back radiograph as a pre-employment screening tool typically involve these industries. Therefore, a continued use of such screening conceivably could affect a large segment of the working population.

Complications arise because within industry there is no unanimous agreement as to what exactly constitutes heavy labor and as a result, what set of workers should be screened is indefinite. Some companies require only applicants for "heavy" work (once that term has been defined within the company) be radiographed while others insist that all applicants, regardless of sex or job function, be examined (14,16).

## EXAMINATION ECONOMICS

There are some well-defined economic costs and benefits of pre-employment low back x rays. The expense of performing the examination and the anticipated reduction in future medical and compensation payments need to be balanced against the potential public health consequences of the resultant radiation exposure.

The actual cost of the examination varies, but in 1973 Southern Railway placed a cost of $45 on each examination (4). The company reportedly expended $200,000 in 1971 for this purpose, which translates into nearly 4,500 examinations. It should be noted that these figures lend credibility to the previous estimate of 150,000 to 1.2 million low back x-ray examinations conducted yearly. In this instance just one company accounts for nearly 1 percent of a mid-range estimate of 0.5 million. There are 90 to 95 railroad companies operating in this country, to say nothing of other "heavy work" industries that use the low back x-ray examination.

A more recent estimate of the cost of a low back x-ray examination was made by averaging the charge for the lumbosacral spine examination at 10 different hospitals around the country. Although these hospitals do not provide a statistically valid sample, the average charge of $53 in 1980 should still be useful for estimating current national costs. In a later section of this report (Radiation Risk), it is estimated that approximately 1 million low back x-ray screening examinations were performed in 1980. Assuming $53 per examination, this would mean that in 1980 about $53 million was spent on this examination.

## COMPENSATION COSTS

Accident histories and disability and compensation costs appear to have convinced some part of the industrial sector that lumbosacral x-ray examinations should be a consideration in hiring practices for certain job categories. According to Becker, more than two-thirds of all spinal structural changes are found in close proximity to the lumbosacral joint (7). He further contended that much of this pathology could be observed by x-ray examination, the findings of which would enable the physician to appraise functional capacities. The statement has also been made that although the etiology of many low back disorders has not been clearly established, the prevalence of lumbar vertebral degeneration is higher and low back disability more common among men who perform heavy work than those who do light work (25).

Back injuries in industry, according to one estimate, represented more than 12 percent of all injuries and 16.1 percent of all lost time (26). A survey by the Ministry of Labour in the United Kingdom revealed that 19 percent of all reported accidents affected the spine and trunk (25). Among coal miners in this study, back injuries accounted for 18.5 percent of all accidents, while for forestry workers the comparable figure was 11.2 percent.

In the United States, industry advocates of pre-employment low back x-ray screening can present impressive statistics to substantiate its claims that back injuries and their concomitant compensation costs virtually force it to make some attempt to apply controls. For example, during the decade from 1940 to 1950 employment increased 31 percent while back injuries increased 132 percent in the State of Ohio (27). Similar figures for New York were 7 percent and 43 percent, and for Minnesota, 57 percent and 80 percent. During the same period, Pennsylvania recorded 6,900 back injuries with compensation alone amounting to $1,500,000. Railroads, an industry particularly susceptible to incurring large compensation costs, paid out $100 million a year during this period. In 1971, 65 U.S. railroads settled 795 low back injury cases for a total cost of $18,515,539 (28).

A 1977 publication states that, in the United States, back injuries cost employers more than $1 billion annually in sick pay and wages for replacement personnel (29). The sensitivity of railroads to this issue is at least partly attributable to the fact that they are not covered under Workmen's Compensation, but instead are subject to the Federal Employer's Liability Act (FELA). Enacted to redress inequities confronting railroad employees in need of compensation, the FELA results in larger money settlements than are possible from other worker compensation statutes. Consequently, following injury, awards for chronic lumbosacral strain average about $32,000. The medical director of one railroad declared that low back problems caused 43 percent of all his firm's work related injury compensation. Figures from another railroad showed that back injuries alone resulted in 2,951 days of work time lost and all other injuries in 2,385 days lost (8).

The employer who institutes pre-employment screening, including low back x-ray examinations, often can point to tangible reductions in both compensation costs and time lost. A 1969 study of applicants for the California Highway Patrol illustrates this and also provides evidence that lumbosacral x rays are being required for ever-increasing job classifications (30). By rejecting applicants with structural weaknesses believed to be more than normally vulnerable to injury, a decrease of 80.6 percent in time lost to injury was effected. On economic grounds, this kind of impact argues for continuation of pre-employment low back x-ray examinations.

When 1,049 prospective stevedores were screened over a period of 3 years and contrasted with a group that had been previously hired without low back radiographs, the latter group was found to have proportionately greater injury and lost time rates (2). In this instance, after pre-employment x-ray examinations were initiated, the company saw a decrease of 82 percent in lost work time, and compensation fell from 375 days in the first 2 years to 13 days in the succeeding 2 years.

Similar results have been documented for other industries. At an electrical equipment manufacturing firm, 7,729 men applying for heavy labor jobs between the years 1950-1959 received low back x-ray examinations (13). In the 15 years following inception of the screening program, disabling back injuries declined 95 percent. The incidence rate of nondisabling back injuries also declined from 2.7 percent to 1.2 percent. For the same period, the U.S. Bureau of Labor data statistics showed a decrease in all disabling work injuries of only 35 percent.

In terms of actual dollar savings, Weyerhauser (wood products industry) determined that a year after beginning the use of low back radiograph examinations, the direct cost of industrial back claims at one plant dropped from $66,000 to $21,000. Two years later this figure was $4,400. Simultaneously, employment had grown from 850 to 1,350. A second plant yielded comparable results (14).

General Dynamics recorded a decrease from 52 to 11 in the number of compensable claims per year for low back injuries over the period 1953 to 1965 (19). Another manufacturer (electrical equipment) compared 5-year periods before and after x-ray screening began (8). Not only was the incidence rate of disabling back injuries observed to fall by 67 percent, but the severity rate, as measured by days lost, also underwent a similar drop. To the firm, this meant a 71 percent decrease in costs of disabling back injuries per million man hours worked by shop men (13).

While also citing improvements in general safety practices, the chief physician of an oil company stated that the major contributor to reduced disability rates and compensation costs was rejection or restriction, through pre-employment examinations, of the employee with a potentially weak back (31). During a 5-year period prior to the use of radiographs, the company paid 0.4 cents per working manhour for medical care, including compensation, and only 0.2 cents in the succeeding 5 years.

Numerous other studies have been done that purport to show very decisive returns to the employer following the introduction of pre-employment low back roentgenograms (7,10-12,14-15,17,31-32). Compensation claims and costs and injury rates declined markedly.

A final note serves to accentuate why industry tries to minimize back injuries. The history of workers with back complaints is such that those who are away from work over 6 months have only a 50 percent possibility of ever returning to productive employment (33). The longer the duration of repair and recovery, the less likely it becomes that the employee will ever resume active work.

## MEDICOLEGAL ASPECTS

To a large degree, the use of pre-employment low back x-ray examinations may be simply a reflection of the increasing medicolegal pressures. A review of the court records of 150 men entering claims for permanent disability against the railroad after sustaining minor injury led to the conclusion that 85 percent of the back conditions of these men existed prior to their specific injuries (27). Breck maintained that old, anterior wedging of the body of one or more upper lumbar or lower thoracic vertebrae could be established in a pre-employment radiograph (1). This would then preclude the possibility of later confusing the condition with an on-the-job injury. In instances such as these, the radiographic evidence appears valuable in reaching equitable settlements.

The Federal Employer's Liability Act, which applies specifically to railroads, increases the medicolegal pressures on the employer. Under this Act, passed in 1906, it is easier for an employee to prove a work-related injury claim than under Workmen's Compensation Laws. To lessen the economic effect of the Act upon their injury claims, railroads resort to radiographs as a means of avoiding employment of individuals with back abnormalities.

Another concern from the medicolegal perspective is that of possible employment discrimination. The point has been made that the railroads' use of the low back x-ray examination misclassifies a substantial number of job applicants as being at increased risk and consequently unfairly denies them employment (29). Asymptomatic persons who are thus rejected for employment may have legal recourse under statutes prohibiting employment discrimination based on actual or perceived handicaps.

## EXAMINATION EFFICACY

The medical community remains divided in its opinion about the efficacy of the examination. For example, a 1978 editorial in the Journal of the Canadian Association of Radiologists called for the avoidance of pre-employment lumbar spine radiographs on the grounds that they lack predictive value (34). This was quickly followed by a dissenting response (35). As pointed out in a 1976 review article, however, the hypothesis that developmental abnormalities predispose an individual to an increased incidence of low back injury is generally not substantiated (36).

A 1952 paper by Colcher found only 55 percent of examined applicants fit for heavy work and stated, without further analysis, that the information gained far transcended the cost of acquiring it (3). At a 1957 Symposium on the Lumbosacral Spine, one physician gave his views on abnormalities thought to be incompatible with good function in men expected to do heavy labor and concluded that the examination was beneficial to industry in employee selection (37). In contrast, another participant at this same meeting adopted the position that many anomalies are not the etiologic basis for lower back complaint (38).

The presumed basis for accepting or rejecting applicants for employment is, of course, the type and extent of low back defect found by examination. Various researchers have categorized and listed the disqualifying factors they have uncovered and/or regard as significant to their screening programs (1,6-8,13,17-18,29,33,39-40). Although these classification schemes tend to be fairly similar, there are disparities among them. The specific tasks of each type work probably account for some of those differences.

Perhaps the most systematic effort in assessing low back conditions relative to eventual job capability has been done by an Ad Hoc Committee of the Industrial Medical Association (formed in 1962) (41). This Committee described criteria for the significance of various conditions detectable by radiographic examinations. In addition, the committee further graded work according to the degree of stress involved. Using these factors, the specific abnormalities that were enumerated were related to a job category that could be performed by a specific worker with one of these identifiable problems. However, no attempt was made to evaluate the worth of low back radiographs used in this fashion.

Because of this lack of agreement as to precisely which physical abnormalities should preclude employment in heavy industry, rejection rates also fluctuate. Reported employee rejection rates range from 9.6 percent to 30 percent (1-2,6-8,13-14,17,31) (Table 2). As mentioned previously, the need for manpower also may occasionally influence these rates. In one study, 51 percent of those seeking work were initially labeled as unfit, but this figure was revised downward in light of the need for additional workers (2).

Table 2. Employee rejection rate in selected low back x-ray screening programs

| Researcher | Reference | Percent Rejection |
|---|---|---|
| McGill | (14) | 10 |
| Burch | (6) | 9.6 |
| Coulter | (8) | 23.7 |
| Stewart | (2) | 30 |
| Becker | (7) | 29 |
| Kelly | (31) | 9.8 |
| Breck | (1) | 15 |
| Leverett | (17) | 29 |

The fact that the predictive value of the examination is disputed is significant from a radiation exposure standpoint. If the examination fails to yield the information for which it is intended, then there is a legitimate cause to question whether there is any benefit to individual workers. Unfortunately, definitive research to resolve this question has not yet been conducted. However, some typical studies that bear on this issue are summarized below.

Fullenlove and Williams, in 1957, reported on a study of radiographic findings in symptomatic and asymptomatic backs (42). A group of workers who had been employed for at least 10 years and were free of back problems was compared with a group of 200 patients referred for myelography. The authors found structural changes of equal frequency in both groups. It was their impression that bony changes may play no part in causing back symptoms.

Twelve years later, Rowe compared a group of employees referred as low back patients with another group who had developed no backaches and found no statistical differences in terms of fixed findings on pre-employment examination (43). As a result, he felt that pre-employment examinations of the lower back were generally ineffective.

During 1967-1971, Weyerhaeuser performed 2,378 lumbosacral x-ray examinations (four views each) and classified them according to criteria suggested by the IMA Ad Hoc Committee (16,41). Two hundred and thirteen subjects were hired with "C" backs (i.e., abnormalities indicating greater than normal risk for sustained heavy work). Because of need for laborers, 209 of these men were assigned to class III or IV jobs (moderate physical activity and heavy physical back stress, respectively). Thus, these 209 subjects comprised a "high risk" group to be contrasted with the "low risk" pool of 1,992 employees hired over the same period. The "high risk" group eventually showed an injury rate of about one-half that of the so-called "low-risk" group. From this it was inferred that the lumbosacral x-ray examinations did not predict or screen out injury-prone applicants.

In much the same sort of study, La Rocca analyzed data from two groups matched for age, sex, and careers in heavy labor but differentiated by evidence of lumbar disability (44). He found that anatomical deviations occurred with equal frequency in both groups and concluded that no developmental or degenerative criterion existed that would allow for reasonable prediction of risk of subsequent lumbar disability.

Gibson et al. compared two groups of steelworkers hired before and after the introduction of low back x rays into an otherwise identical pre-placement medical examination (45). The inclusion of low back x-ray screening was found to have no significant effect on the incidence of low back pain in these two groups.

Even when positive findings have been noted on an x-ray examination, their meaning is not always clear. Diagnostic interpretation of lumbar spine radiographs of patients requesting job related compensation was seen to vary critically in 46 percent of cases

reviewed by a team of three radiologists (46). Rockey et al. analyzed process and outcome data from 440 patients with back pain (47). They concluded that for patients under age 50, x-ray examinations of the lower back have only minimal diagnostic value.

Splithoff compared 100 patients with backache and an equal number without, in terms of incidence of various abnormalities (12). Roentgenographic findings were similar for both groups. At another industrial plant where all production workers hired during the period 1951-56 were given pre-employment x-ray examinations, 409 cases of back trauma were analyzed with respect to preexisting defects (49). There was no significant variation between the incidence of back injury in employees with radiographically observable defects and in employees without such defects. Some differences were noted, however, in severity of injury as measured by loss of work time. While injury severity was essentially the same for the group with negative x-ray findings and those with osteoarthritis and transitional vertebrae, groups with spondylolisthesis and prespondylolisthesis exhibited a 50 percent increase in time loss over the negative group. Time loss doubled for those having disc space abnormalities, and was 13 times as great for prior surgical defects. On this basis, the company decided that spondylolisthesis, prespondylolisthesis, intervertebral disc abnormalities, or prior surgical defects should be grounds for rejection for employment.

When a mining company elected to hire workers with known spinal anomalies, because of their experience, it became possible to compare them with screened groups employed by other companies engaged in the same kind of mining activity (32). Thus, two types of low-back conditions were described. "Contributing" conditions were those factors felt to be definitely associated with increased frequency and severity of injury. The "noncontributing" factors essentially defined the "normal" back. The incidence of injury for the group with "contributing" conditions was found to be almost 3 times that of the group without such conditions. The patients who did not have anomalies lost about half as much time as the other group.

Industry also endorses screening on the basis of studies such as the one in 1970 that investigated low back pain and occupation (50). In the study, 2,887 controls and 429 lower back pain complainants were compared in categories ranging from bank clerk to heavy industrial worker. Findings indicated that prolonged work in any occupation produces proneness to lower back pain, but that this tendency is more pronounced for the physically demanding industries.

The uncertainty that persists relative to efficacy may be because virtually all of the studies that have been done have readily identifiable limitations and biases. Investigators tend to subjectively devise their own clinical criteria to evaluate applicants in order to meet the particular needs of the industries they serve. Moreover, the many variables associated with a working population and environment make it difficult to plan and execute controlled studies.

Advocates of the pre-employment low back x-ray examination justify their position mainly on the basis of decreased injury rates and less time away from work (3,8-10,49). Those who oppose use of the examination do so because they claim it has no predictive value. These are not necessarily contradicting positions.

## RADIATION RISKS

The radiation exposure from a low back x-ray examination is relatively high for diagnostic radiology. Significant doses to both the active bone marrow and the male or female gonads can occur. Thus, there is potential for somatic injury (i.e., injury to the individual) as well as potential for genetic injury (i.e., injury to the individual's progeny) from low back radiography.

The exact magnitude of the radiation risk from diagnostic levels of radiation has been debated at great length and, currently, is somewhat open to question. Direct evidence of

radiation injury is only available for dose levels somewhat higher than diagnostic levels. The risk associated with radiation doses equivalent to diagnostic radiology is usually estimated by extrapolating effects observed at much higher doses and dose rates. It is, in fact, the method of extrapolation that is at the heart of the controversy (e.g., for a complete discussion, see the report of the Committee on Biological Effects of Ionizing Radiation or BEIR III Report (51)). Generally speaking, the conservative public health approach has been to assume that radiation bioeffects at low doses and dose rates are linearly proportional to the effects known to occur at higher doses and dose rates.

In addition to assuming a linear relationship between radiation dose and effect, two other assumptions usually are made. First, it is assumed that there is no threshold below which effects cannot occur. No matter how small the radiation exposure, it is assumed that there is some damage. Second, it is assumed that the effects of all radiation exposures are additive. In other words, the net effect of a series of exposures to a person or to a population will be the same as a single exposure equal in magnitude to the sum of the individual exposures. This is tantamount to saying that little or no healing occurs between successive exposures. For certain types of radiation bioeffects, there is some evidence to support these assumptions. However, using these assumptions in all instances is more an act of faith in the conservative approach to public health issues rather than a reflection of hard scientific evidence. Recognizing that such controversy exists, the calculations that follow employ the linear, nonthreshold hypothesis of radiation dose and effect.

One can now estimate the radiation risk incurred by the use of low back radiography, but first, we must determine the population at risk. In 1970, 3.6 million low back x-ray examinations were performed in the United States (52). It was estimated that between 0.15 and 1.2 million of these may have been pre-employment examinations. Recently, BRH estimated, by extrapolating data from surveys taken in 1964 and 1970, that 4.3 million lumbar spine x-ray examinations occurred in 1978 (53). This means that between 0.18 and 1.4 million screening examinations may have occurred in that year.

A recent study in the State of Michigan estimated that about 25 percent of 235,000 annual lumbar spine x-ray examinations were done for pre-employment screening purposes (22). Extrapolated nationwide, this would mean that (4.3 million) x (0.25) or 1.1 million lumbar spine x-ray examinations were performed as pre-employment screens in 1978. This is consistent with the above estimated range. For the purpose of this report, it will be assumed that 1 million examinations per year are done for screening purposes.

## CALCULATION OF SOMATIC EFFECTS

A typical lumbar spine x-ray examination consists of from three to five views: one anteroposterior film, one or two lateral films, and one or two obliques. The major organ at risk for somatic injury from this x-ray examination is the red bone marrow. A 1976 study by the BRH estimates the following mean active bone marrow doses from lumbar spine x-ray examinations (54):

| View | Dose |
|---|---|
| A-P | 103 mrad |
| Lateral | 151 mrad |
| Oblique | 67 mrad |

Depending upon the number and type of views used, the mean active bone marrow dose could range from about 320 mrad to about 540 mrad. In what follows, the average of these numbers, 430 mrad, will be used; however, it should be noted that the dose can be quite a bit larger or smaller than this depending upon the number of views taken, the technique factors used, the speed of the imaging system, and so forth. The annual active bone marrow dose to the population from lumbar spine screening examinations is then (0.43 rad/examination) x (1 million examination) = 430,000 rad.

The risk of leukemia induction from ionizing radiation exposure to the red bone marrow, as given in the BEIR III Report is in the range of 1-2 cases/year/million person-rem (51). This means that we would expect 1-2 cases of leukemia per year for the entire period of risk (approximately 20 to 25 years in this instance) as a result of each million rem dose to the population. For the purpose of this calculation, we will assume a risk of 1.5 cases/year/million person-rem.

Since for diagnostic x rays the rem and the rad are numerically equal, we expect (430,000 rad) x (1.5/leukemia cases/$10^6$/rad/rem) = 0.65 leukemia cases per year for the period at risk resulting from 1 year of low back x-ray screening. Since the population is at risk for about 22 years, this translates to 14 cancer cases induced because of 1 year's screening use of the lumbar spine x-ray examination. Note that this is equivalent to saying that if there are 1 million lumbar spine screening examinations each year for a period equal to the period at risk plus the latent period of the disease, we will reach an equilibrium condition where 14 cases of leukemia will be induced each year.

A word of caution must be given in interpreting this type of calculation. This is merely a mathematical exercise that is useful in demonstrating an approximate level of risk. It is best used, perhaps not in an absolute sense, but in a relative sense, useful for comparing alternative courses of action.

## CALCULATION OF GENETIC EFFECTS

Since the low back x-ray examination can expose both the male and female gonads to ionizing radiation, genetic consequences of screening may be anticipated. In general, genetic effects can be divided into two categories: demonstrably genetic and genetically related diseases in future generations and a general increase in ill health because of less overt genetic deficiencies. For a more complete discussion, the reader is referred to the BEIR III Report (51).

The mean gonad dose in 1970 from a lumbar spine x-ray examination has been calculated to be 218 mrad for males and 721 mrad for females (55). Because the large majority of low back screening examinations are performed on young males, the gonad dose for males will be used to simplify the calculations. It should be noted, however, that the estimates should be revised upward to account for the proportion of females who are, in fact, screened.

The BEIR I Report estimates that 300 to 7,500 genetically related diseases will occur per million live births whose ancestors had received a continuous gonad dose of 5 rem per generation (56). It will be assumed first that the acute exposure from diagnostic x-ray examinations has the same effect as a continuous exposure. Second, it will be assumed that the genetic effects are due principally to the screening of young males, i.e., approximately 20-29 years of age. This latter assumption is reasonable if, in fact, the primary purpose of low back screening radiographs is for placing job applicants in appropriate positions. Presumably then, the individuals examined will be mainly those starting off in their careers. Furthermore, the primary use of the examination is for prospective employees in positions involving manual labor, which is an area that is under-represented by female employees.

According to a 1970 report, males aged 20-24 would be anticipated to father, on the average, 2.6 future children (55). For males aged 26-30, the number is 2.0. If we assume two future children for each exposed individual, the 1 million screening x-ray examinations would affect 2 million future births. Scaling the risks quoted from the BEIR Report, one would anticipate between 26 and 650 demonstrably genetic diseases from low back x-ray screening at equilibrium.

The second genetic effect mentioned above is a general increase in ill health expressed in future generations. The BEIR Committee used an estimate of the magnitude of this effect to derive a cost per rem of gonad exposure in terms of 1972 health care costs (see pp. 78-79 of the BEIR I Report). The value derived was $12 to $120 per person-rem. In terms

of 1980 health care costs this would translate to about $20 to $200 per person-rem. Since the gonad dose from low back screening x-ray examinations is about (0.218 rem per examination x 1,000,000 examinations) or 218,000 rem, this means that the annual cost of future ill health relatable to the screening is in the range of $4.4 million to $44 million. This, as well as the other effects calculated, are listed in Table 3.

Table 3. Summary of radiation costs attributable to low back x-ray screening

| Effect | Cost/year (at equilibrium) |
|---|---|
| Leukemia | 14 cases |
| Genetic diseases | 26-650 cases |
| Genetic ill health | $4.4-$44 million |

## STUDY LIMITATIONS

None of the studies cited here definitely answers the question whether the low back x-ray examination is a valid predictor of future back trauma. An ideal study could be either retrospective or prospective in nature. In either case, however, a number of these variables would have to be controlled. To date, a well-controlled study has not been performed. There are many reasons for this limitation of past studies. One handicap of a controlled study is the great mobility of the present day worker. It is very difficult to do an indepth critique of disabilities when the average observation time of one worker at one job is only about 2 years.

Another limiting factor is the difficulty in controlling variables when comparing groups of human subjects. The age, health status, amount of daily exposure to heavy labor, and even the subject's outside activities can influence the findings.

Also, there are times when employment demands sometimes bias the selection process. If there is a lack of "medically qualified" applicants, then industry will hire applicants who would otherwise be rejected.

The low back x-ray examination is not the final word. Many people who experience low back injuries display no spinal abnormalities when radiographically examined. In contrast, many people with congenital anomalies work for years without ever experiencing low back pain or injuries.

Studies in this area are also hampered by a lack of firm agreement regarding the meaning of various radiographic findings. In addition, radiology clinics employ different techniques in making the x-ray examination. Not all radiology facilities and operators are of similar quality.

Finally, medicolegal concerns continue to distort the employee selection process. The medicolegal protection and economic savings perceived by employers foster the continuing reliance on the low back examination.

## SUMMARY

The low back pre-employment x-ray examination as part of a routine screening program is a relatively high diagnostic radiation exposure procedure. While precise figures are unavailable, a substantial number of these examinations are performed each year. This situation prevails in the face of a general consensus among the medical community that the examination does not have high predictive value for future back problems.

There is no generally accepted guidance regarding how the examination should be used. Development of specific criteria to foster more informed and efficient use of the low back x-ray examination in a screening context may alleviate some of the medicolegal and economic problems that account for the examination's use. In turn, both economic and radiation exposure savings could be achieved.

## RECOMMENDATIONS

First, it is necessary to determine more accurately parameters such as the frequency of the examination and the population at risk. In order to address the proper use of the examination, a minimum set of baseline data is required. Criteria for the selection of patients for the low back x-ray examination should be established. Then, in the instances where the examination proves to be useful, there should be guidelines for optimum protocol. This would mean arriving at guidelines for the number of views, amount of exposure, image-receptor system, patient protection, and, perhaps, even the facilities used for the examination (factory or doctor's office versus established radiology laboratory). Finally, recommendations should be developed and the support of organized medicine sought to establish appropriate standards of practice and, thus, counter medicolegal pressures. At present, workmen's compensation laws differ from State to State and between the State and the Federal Government. Furthermore, workmen's compensation requirements should be standardized. This lack of standardization remains a deterrent for equitable solutions to medicolegal problems arising from low back injury on the job.

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